CERES Instrument Status Flight Models 1-6 (FM1-FM6)

Kory Priestley

CERES Instrument Working Group

CERES Fall Science Team Meeting
October 12 - 14, 2022

CERES Instrument Working Group

CERES Instrument Working Group

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Instrument Operations	**Data Management**	**Cal/Val**
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Carol Kelly	Nelson Hillyer	Nitchie Smith
Ethan Ames	Dianne Snyder	Z. Peter Szewczyk
		Robert Wilson

CERES Instrument

- CERES ***measures*** radiation from the visible through far-infrared spectral regions-
  - Reflected solar Radiances (Shortwave Channel, 0.3 – 5 microns)
  - Total Outgoing Radiances (Total Channel 0.2 – 100 microns)
  - Outgoing Longwave Radiances (Longwave Channel, 8-12 microns FM1-FM4, 5-35 microns FM6)
- CERES Science team ***produces*** Radiative Flux values/products from these radiance measurements

- Instrument was designed, built and tested by NGAS (formerly TRW, Redondo Beach, CA).
- Contains three sensor assemblies, each with Cassegrain telescopes and thermistor bolometer detectors.
- Three sensor channels are co-aligned and mounted on a spindle which rotates about the elevation axis.
- Terra spacecraft- Flight Models 1 and 2 (FM1, FM2)
- Aqua spacecraft- Flight Models 3 and 4 (FM3, FM4).
- Suomi NPP spacecraft- Flight Model 5
- NOAA 20 spacecraft – Flight Model 6

CERES Instrument Status Summary

- **All CERES instruments continue to demonstrate stable performance.**
  - **NOAA-20/FM6 instrument continues to perform nominally.**
  - **S-NPP/FM5 is currently operating in Biaxial mode.**
  - **Terra/FM2, Aqua/FM4 are primarily operating in Biaxial mode.**
  - **Validations show that all instruments are performing consistently.**

- **Level 1 Data products**
  - **NOAA-20/FM6 Edition 1 gains have been delivered through August 2022.**
  - **S-NPP/FM5 Edition 2 gains and SRFs have been delivered through July 2022.**
  - **Terra and Aqua instruments' Edition 4 gains and SRFs have been delivered through July 2022.**

CERES Instrument Operations Summary

- **Operational Modes:**
  - Terra/FM1, Aqua/FM3, NOAA-20/FM6 are operating in the crosstrack mode.
  - Terra/FM2 operating in biaxial mode from November 1, 2021 to September 30, 2022.
    - Currently conducting GEO-SAT intercomparison operations for the month of October 2022.
  - Aqua/FM4 is operating in biaxial mode since July 14, 2021.
  - S-NPP/FM5 is operating in biaxial mode since Oct 1, 2019; *Full* biaxial mode since Mar 23, 2020.

- **Terra FM2 instrument is conducting GEO-SAT intercomparison operations throughout October 2022.**
  - Conducting daily scans, primary mode will be crosstrack.
  - Every orbit intercomparison with geostationary satellites, similar to GERB campaign.

- **Inter-comparison operations conducted in summer 2022:**
  - Terra/FM1 – S-NPP/FM5: May 1 – Jul 31, 2022
  - Terra/FM1 – NOAA-20/FM6: May 1 – Jul 31, 2022
  - Terra/FM1 – Aqua/FM3: Jun 1 – 30, 2022
  - Terra/FM2 – GERB: Jun 1 – 30, 2022

CERES Instrument Operations Summary

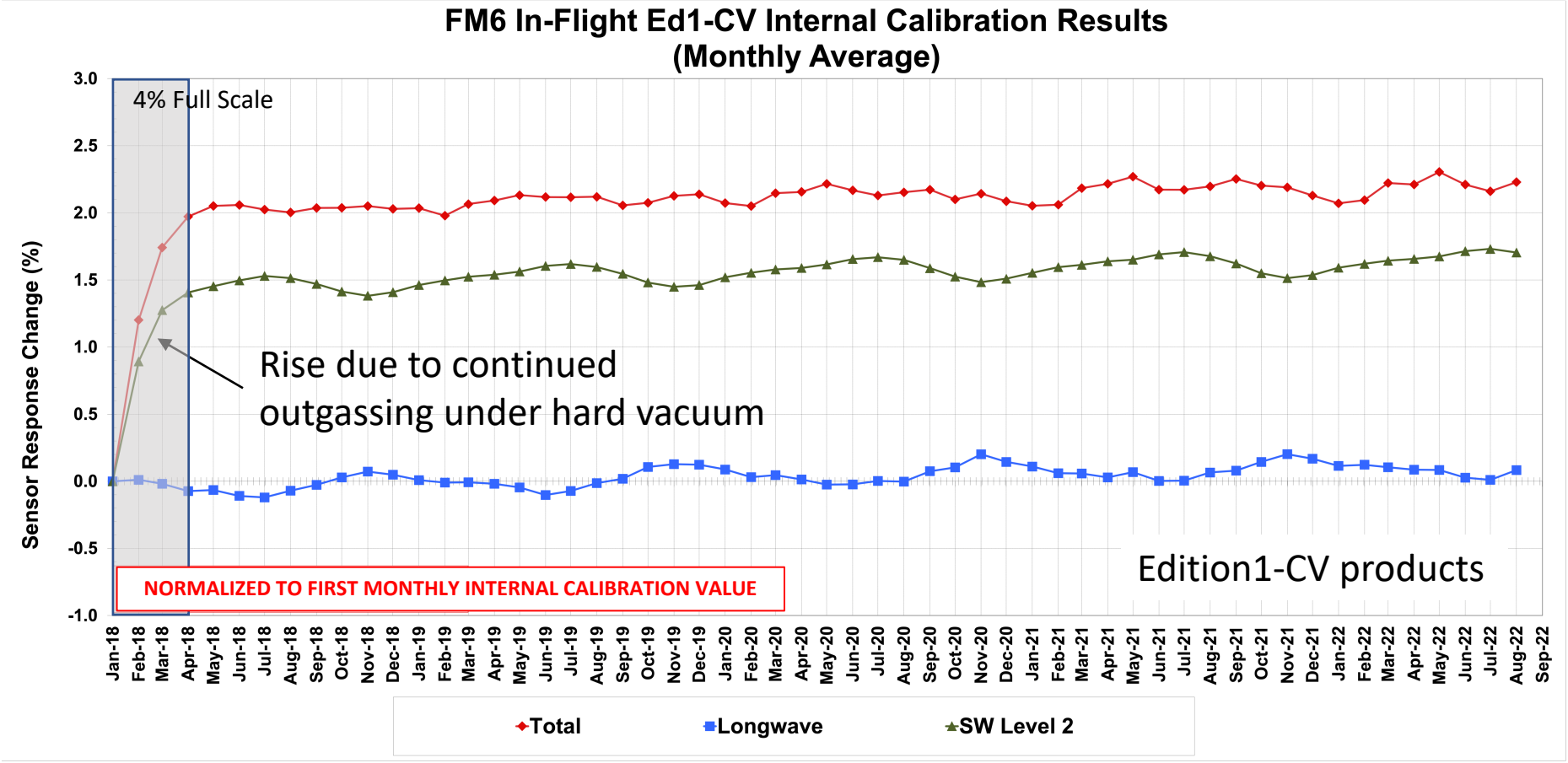
- **S-NPP spacecraft anomaly resulted in no FM5 Earth Observation data for the month of August 2022.**
  - **FM5 entered SAFE Mode (loss of earth observations) at 16:25 on 7/26 in response to the S/C anomaly.**
  - **FM5 entered SURVIVAL Mode (i.e. Operational Power Removed, along with all other instruments) from 7/29 until (~16:07 UTC) until 8/9 (~20:16 UTC).**
  - **During instrument re-activation FM5 had an azimuth stall indication and required assessment before returning to normal operations.**
  - **FM5 was placed into crosstrack mode on 9/1 for one month and returned to full biaxial mode 10/1.**
  - **No FM5 internal calibrations were conducted during August 2022 due to these issues so no FM5 Ed2 gains will be available for that month.**

- **Terra spacecraft to begin conducting constellation exit maneuvers.**
  - **First maneuver scheduled for October 12, 2022.**
  - **Second maneuver scheduled for October 19, 2022.**

NOAA-20/FM6 Instrument Status

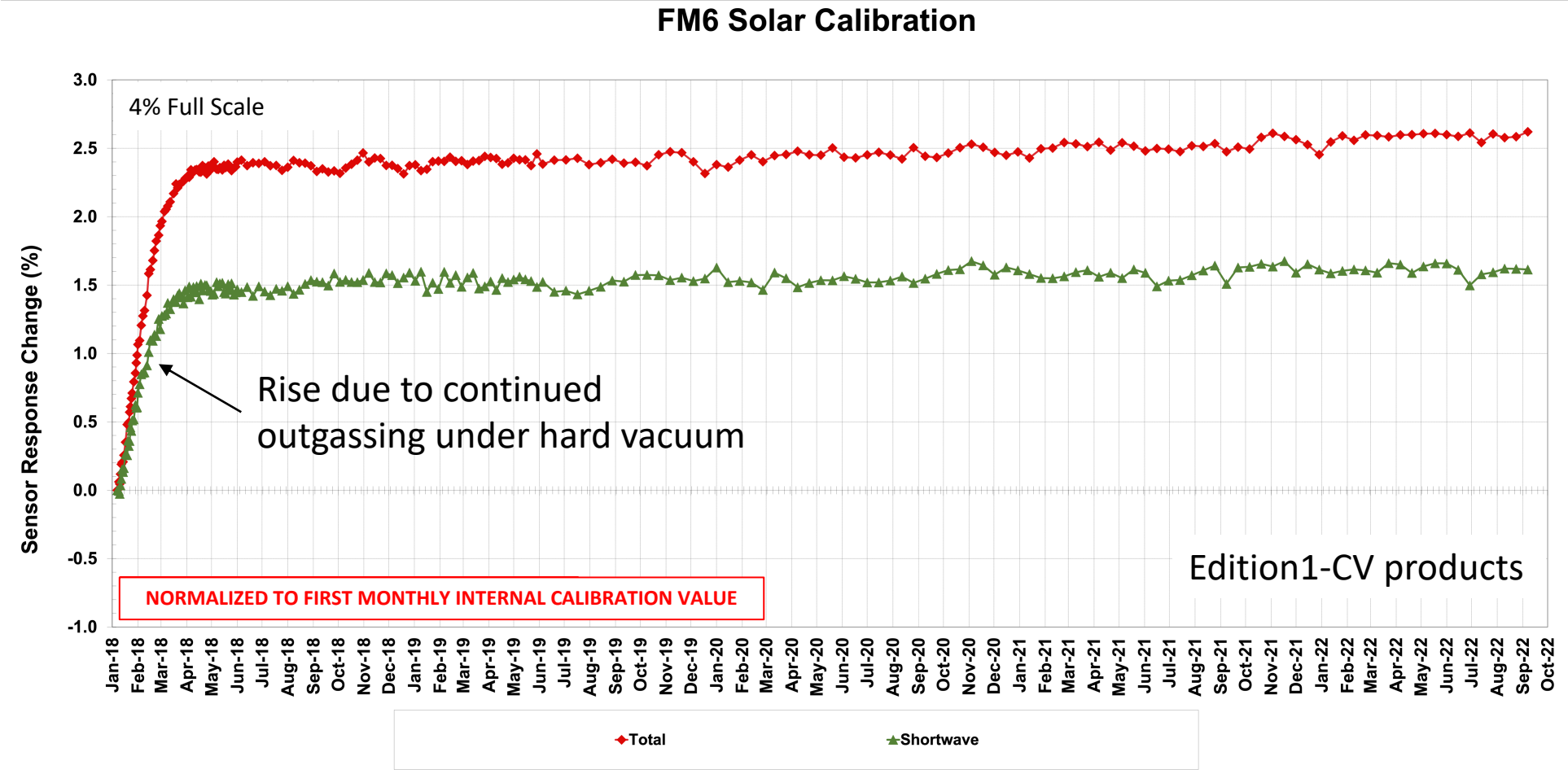
FM6 Internal Calibration

- **For SW and TOT channels, the responses to the on-board sources (SWICS lamp and Blackbodies) continue to be quite stable after the initial rise of ~1.5% (SW) and ~2% (TOT) since start of mission.**
- **LW Channel (calibrated using blackbody) continues to show very little change.**



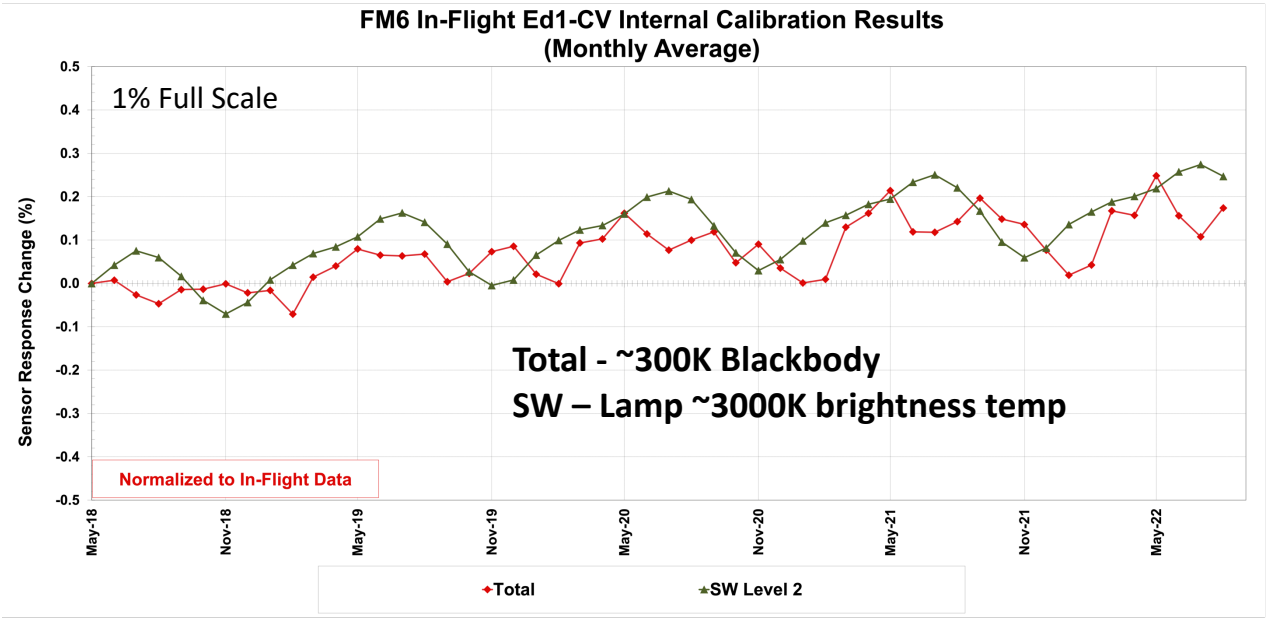
FM6 Solar Calibration

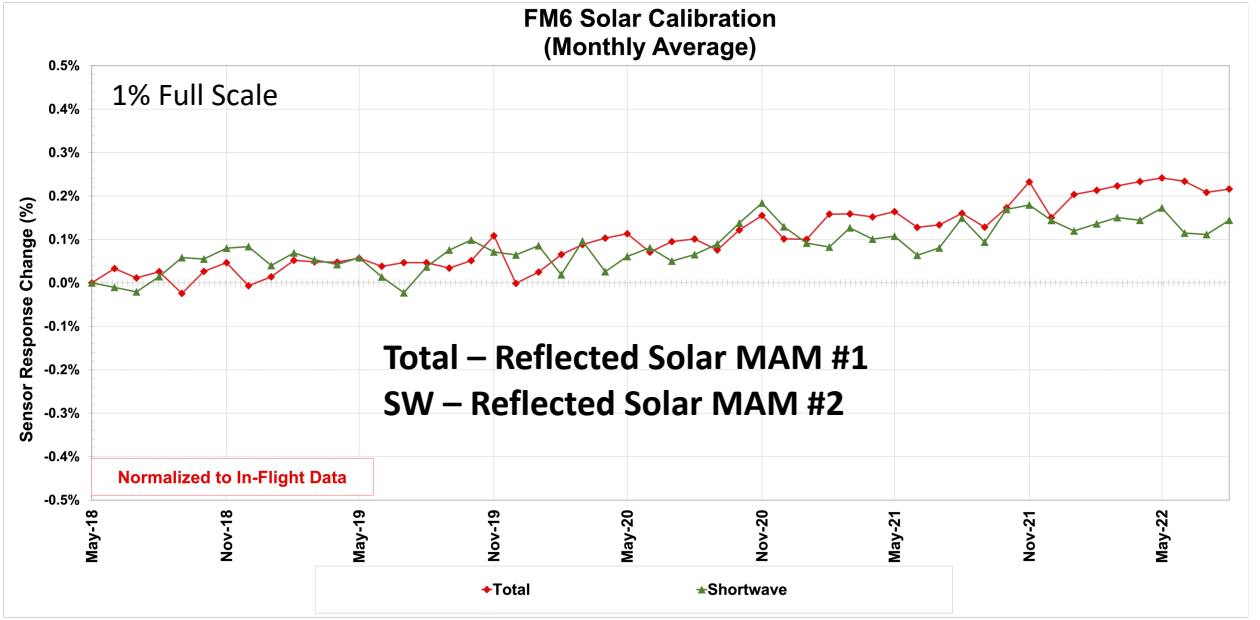
- **Response of the SW and TOT channels while viewing the MAM that is illuminated by the sun.**
- **After the initial rise of ~1.5% for SW, and ~2.3% for TOT, the response is quite stable.**



FM6 Calibration- Internal and Solar Cal Since May 2018

FM6 Internal and solar calibration results consistently show about 0.2% change since May 2018, demonstrating that the MAM is very stable.





Internal Calibrations

Solar Calibrations

Edition1-CV products

Demonstrates Consistent Stability of the TOTAL channel across very different Calibration target spectra

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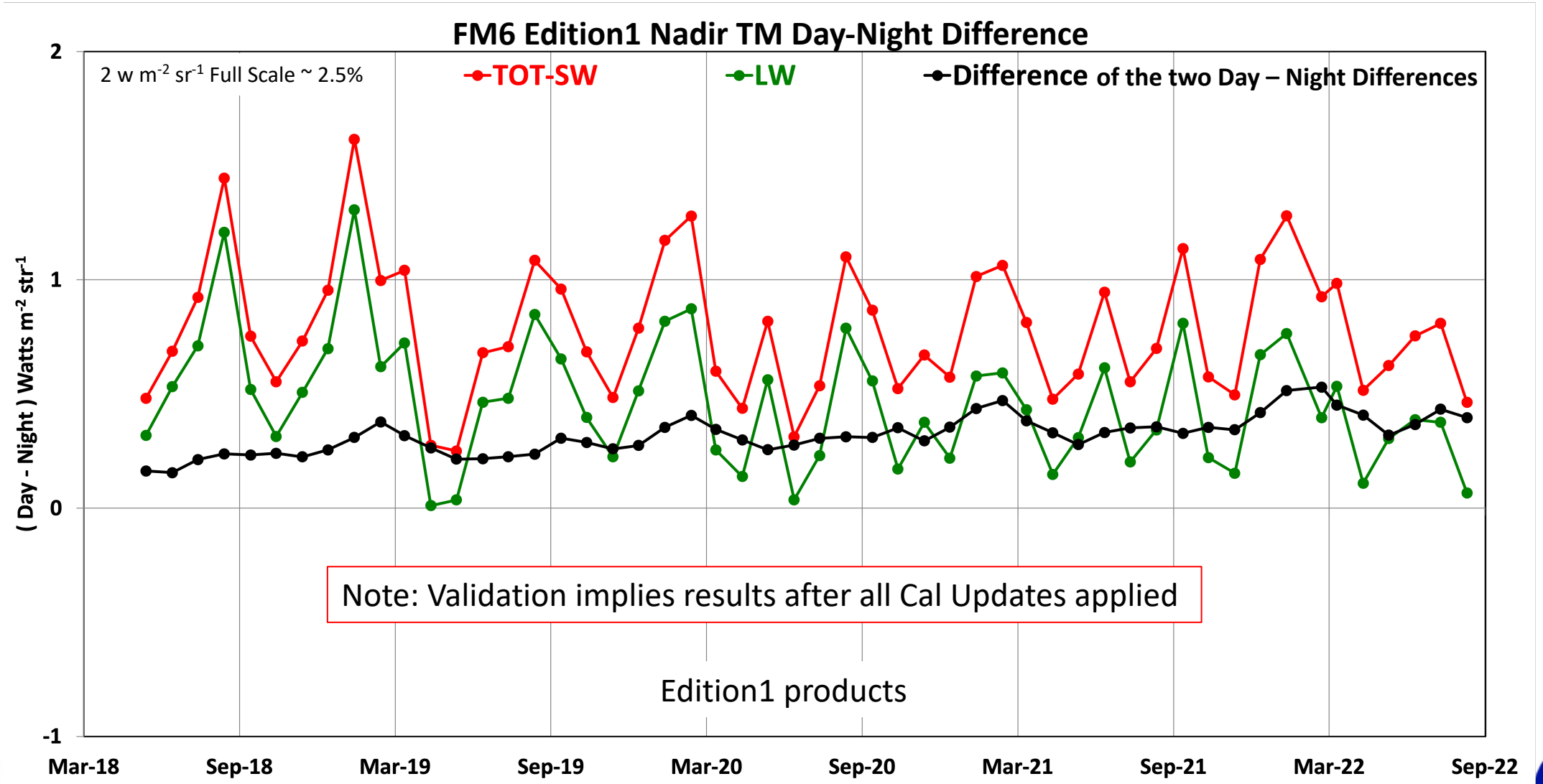
Validation – Tropical Mean

- **Average of the ES-8 Nadir radiances over Tropical ocean (20^0N-20^0S) scenes under All-sky conditions.**
- **Two sets of TM Day-Night Differences (DN) are calculated:**
  - **TOT and SW sensors**

    DN= TM_D(TOT-SW) - TM_N(TOT)
  - **LW sensor (FM6 Has Broadband LW Channel, FM1-4 use 'trained' LW N2BB algorithm)**

    DN= TM_D(LW) - TM_N(LW)
- **Trending the difference in the two DN values highlights any inconsistencies in the Reflected Solar regions of the TOT and SW sensors.**

Validation - FM6 Tropical Mean

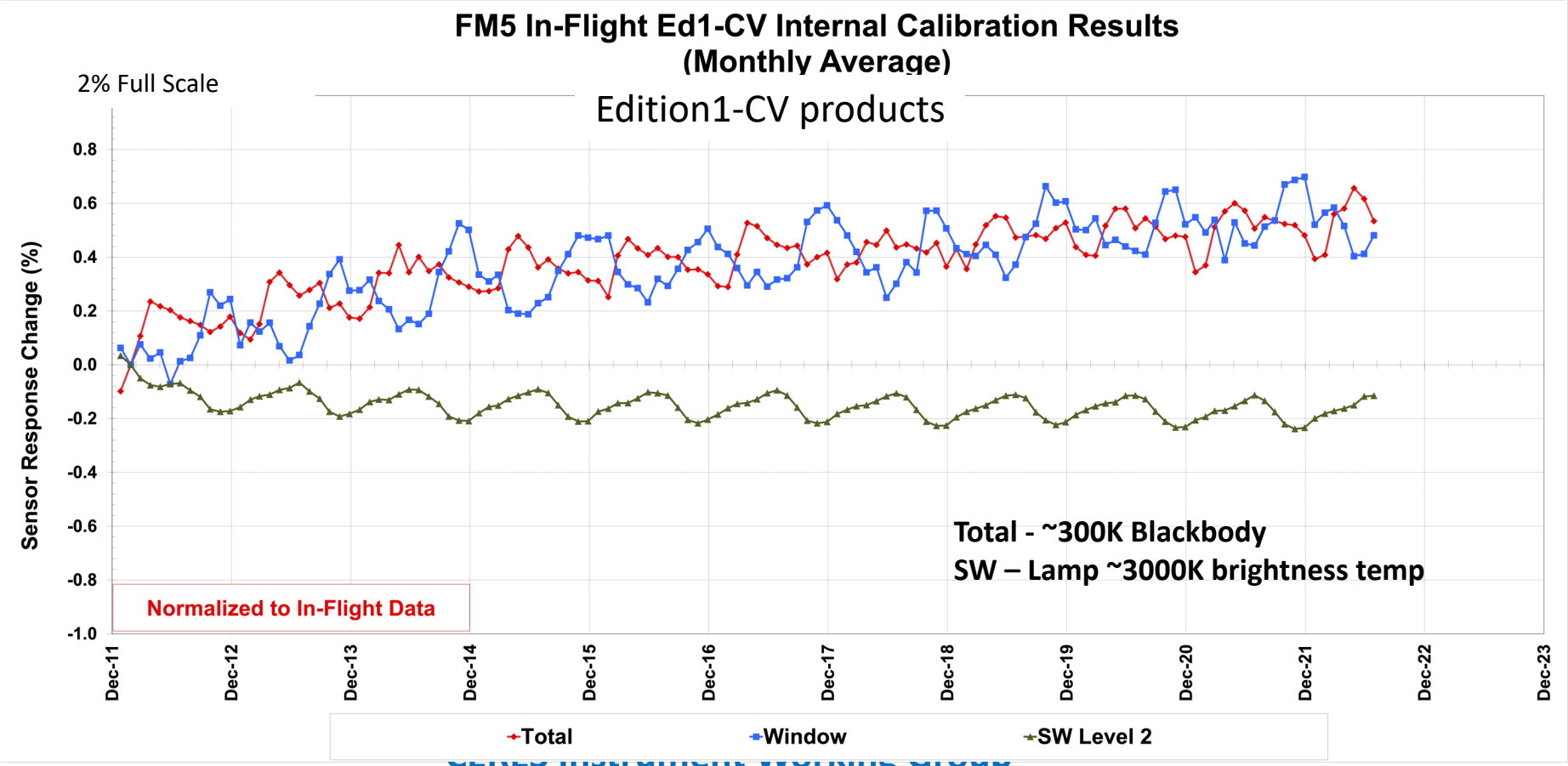


S-NPP/FM5 Instrument Status

FM5 Internal Calibration

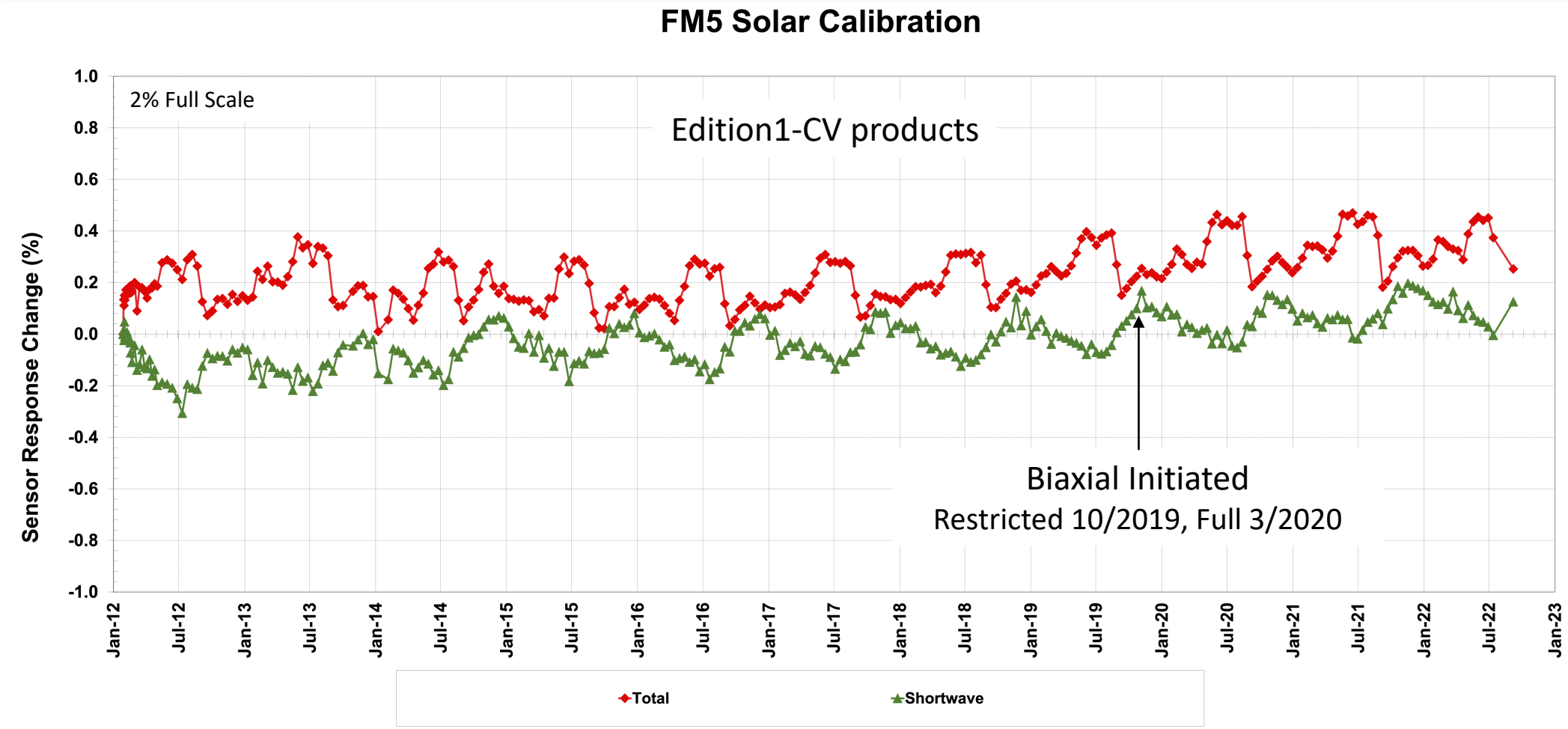
In response to blackbodies, the FM5 TOT and WN sensors show a ~0.5% rise since start of mission.

SW channel's response to the SWICS is stable at <0.2% since start of mission.

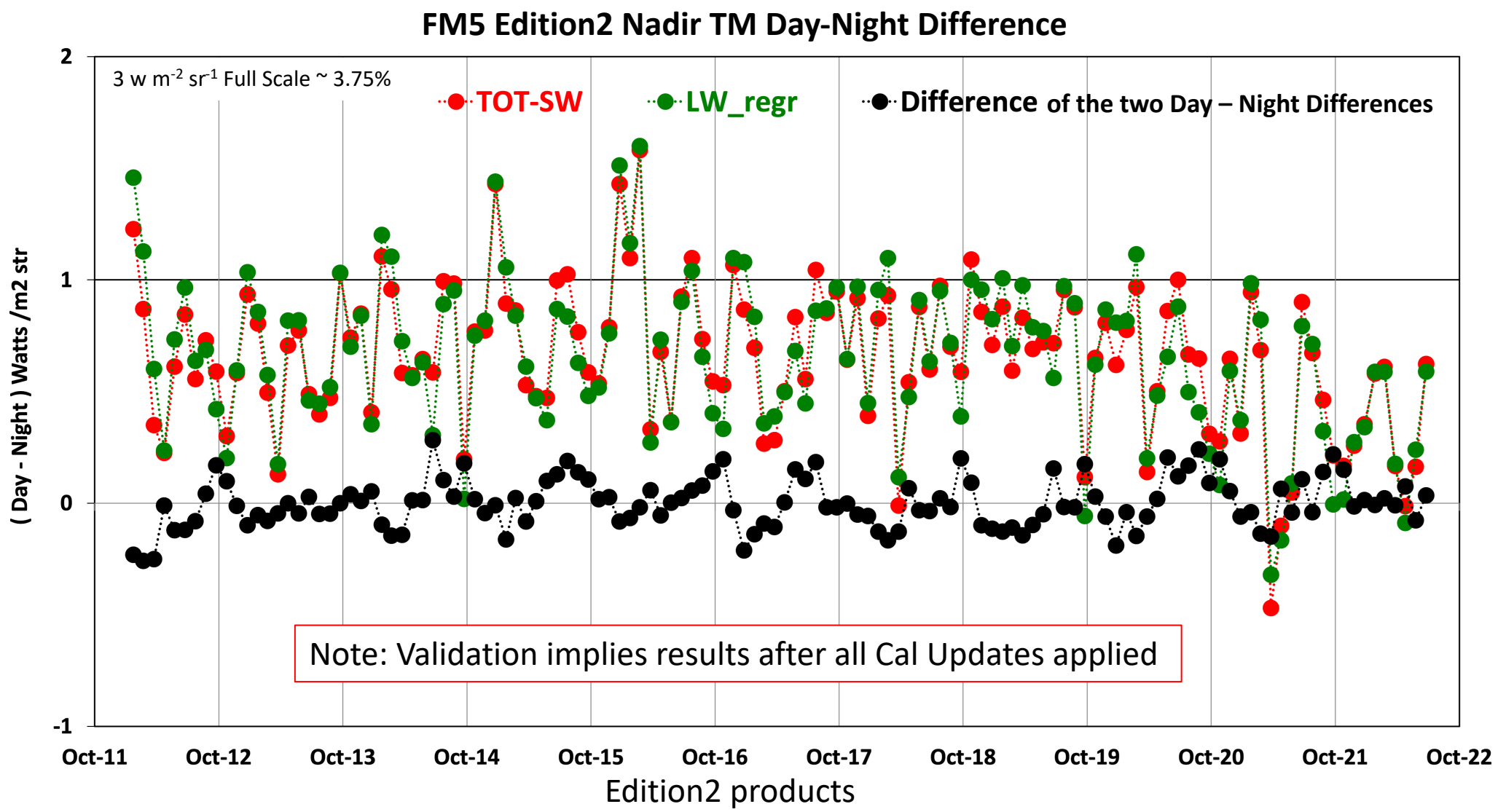


FM5 Solar Calibration

- **FM5 Solar calibration results show the MAMs are very stable.**
- **TOT and SW responses show a slight upward trend in latter part of mission.**



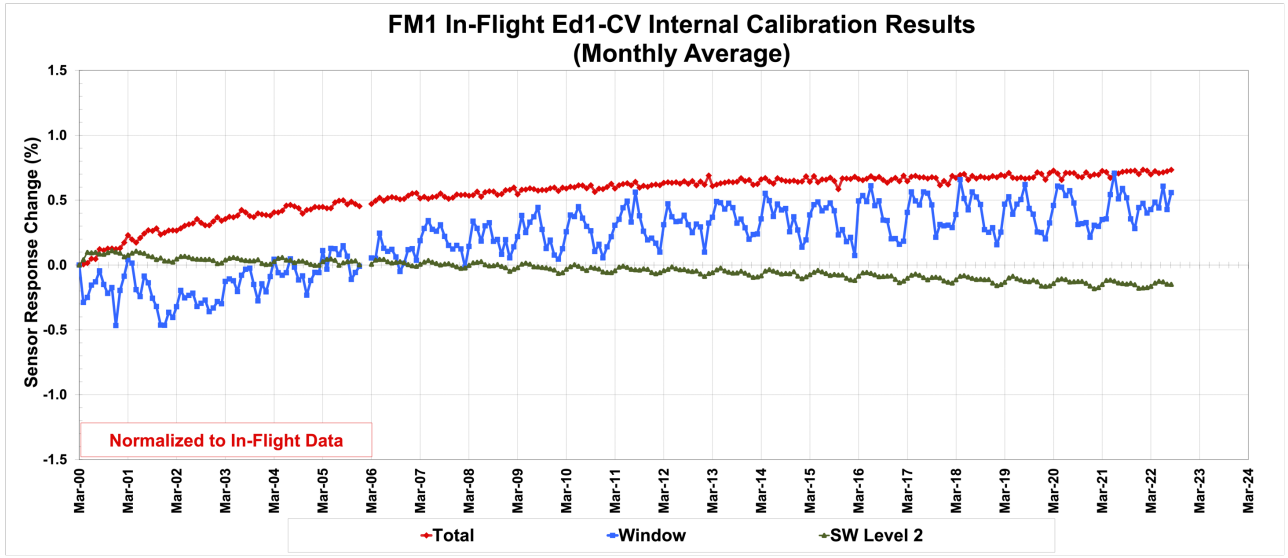
Validation- FM5 Tropical Mean

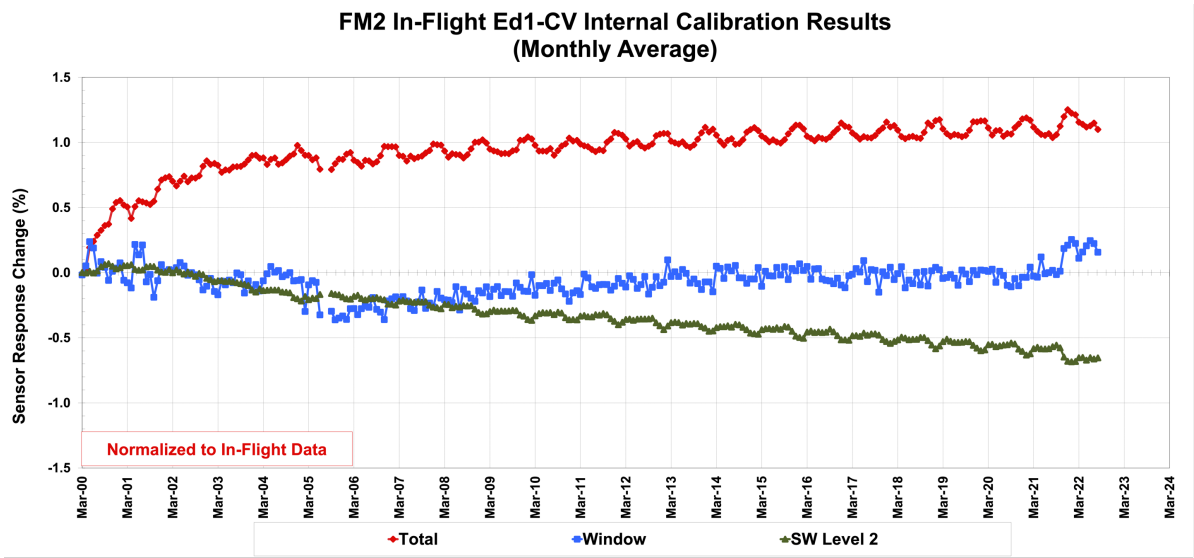


Terra & Aqua
FM1-FM4 Instruments' Status

Terra- FM1 & FM2 Internal Calibration

- **For FM1, TOT channel shows ~0.7% rise, SW channel shows ~0.1% drop, and WN channel shows a rise of ~0.4% since start of mission.**
- **For FM2, TOT channel shows ~1.2% rise, SW channel shows ~0.6% drop, while WN channel shows ~0% change since start of mission. Transitioned to BIAX in November 2021.**





FM1 Edition1-CV products **FM4**

Total - ~300K Blackbody
SW – Lamp ~3000K brightness temp

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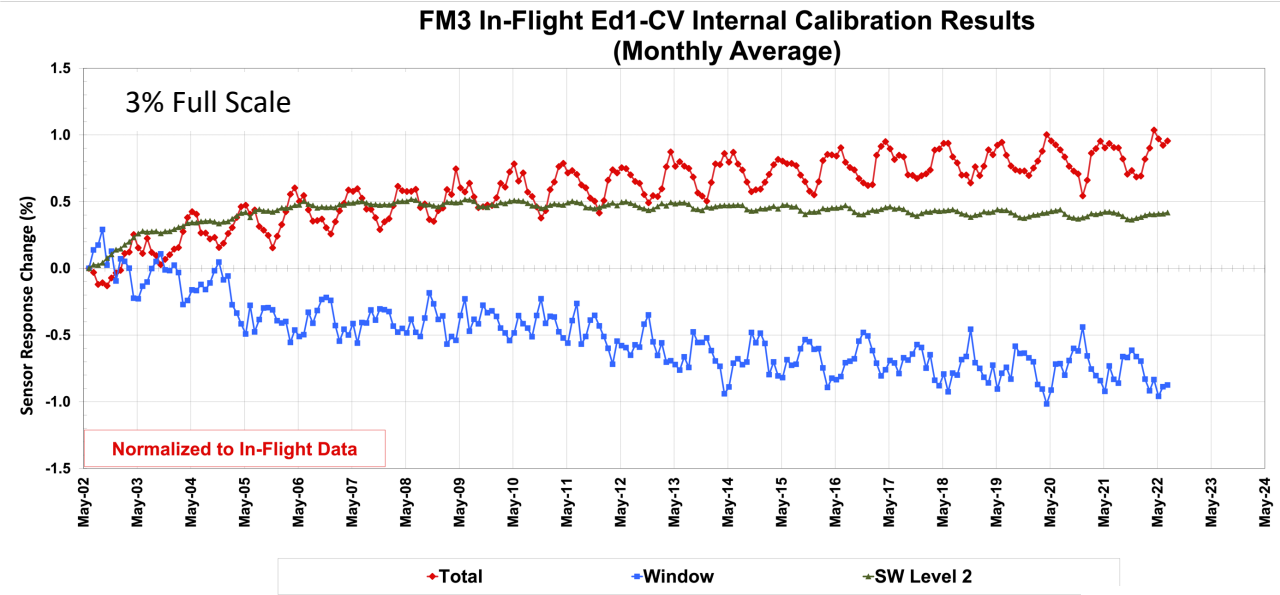
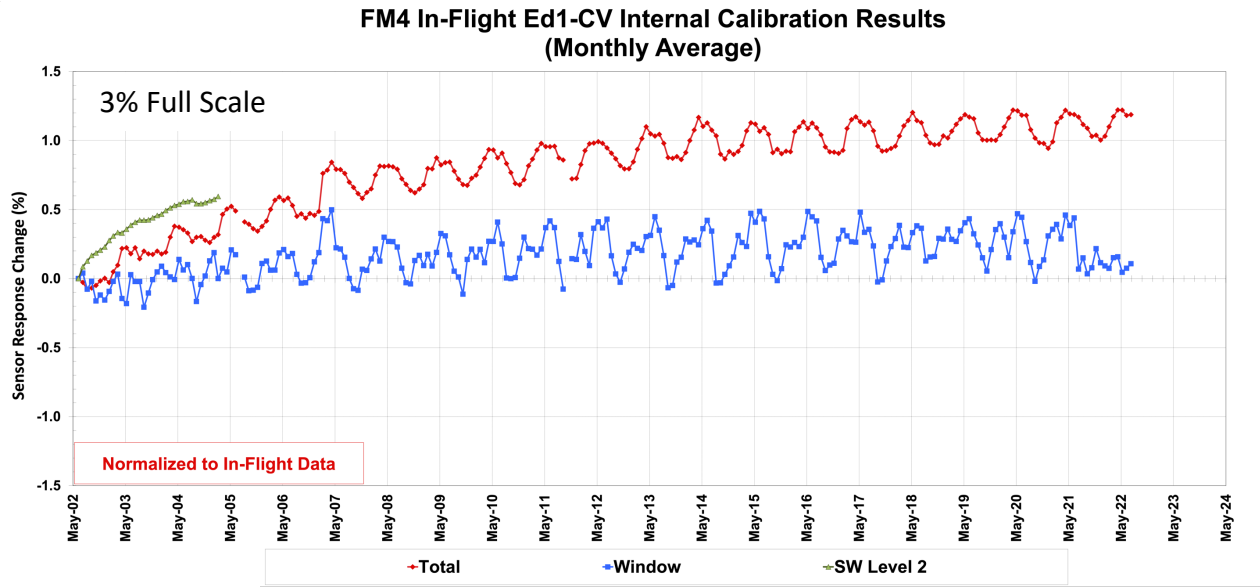
Aqua- FM3 and FM4 Internal Calibration

- **For FM3, TOT channel shows ~0.8% rise, SW channel shows ~0.4% rise, and WN channel shows ~0.8% drop since start of mission.**
- **For FM4, TOT channel shows ~1% rise, while WN channel shows ~0.25% rise since start of mission. Transitioned to BIAX in July 2021.**





Edition1-CV products

FM3 **FM4**

Total - ~300K Blackbody
SW – Lamp ~3000K brightness temp

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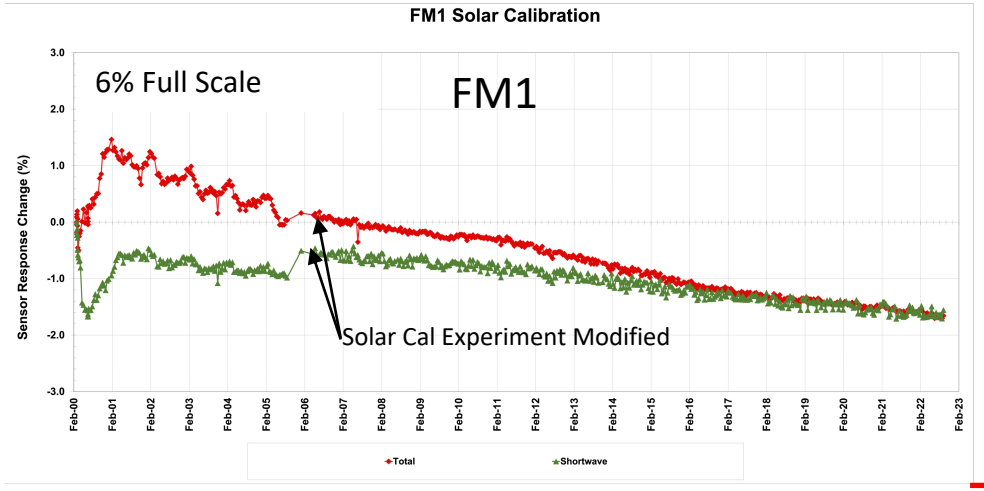
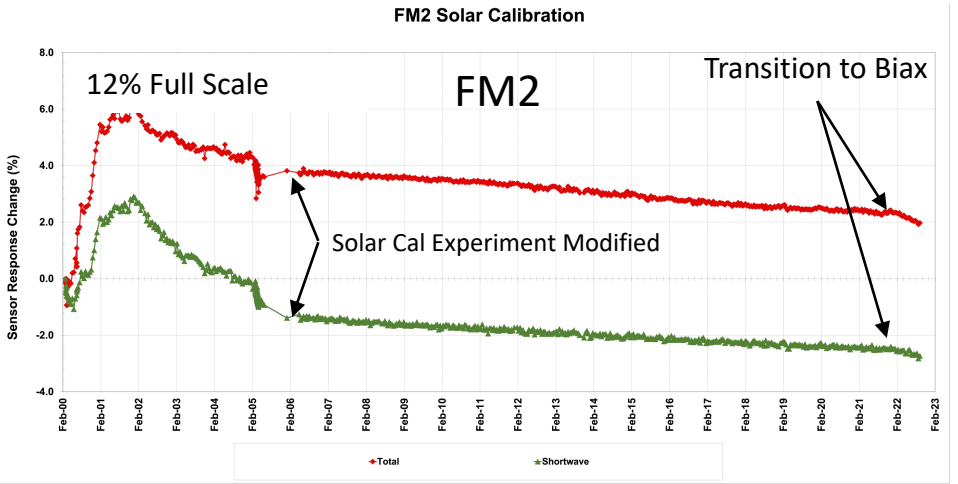
Terra & Aqua Solar Calibration

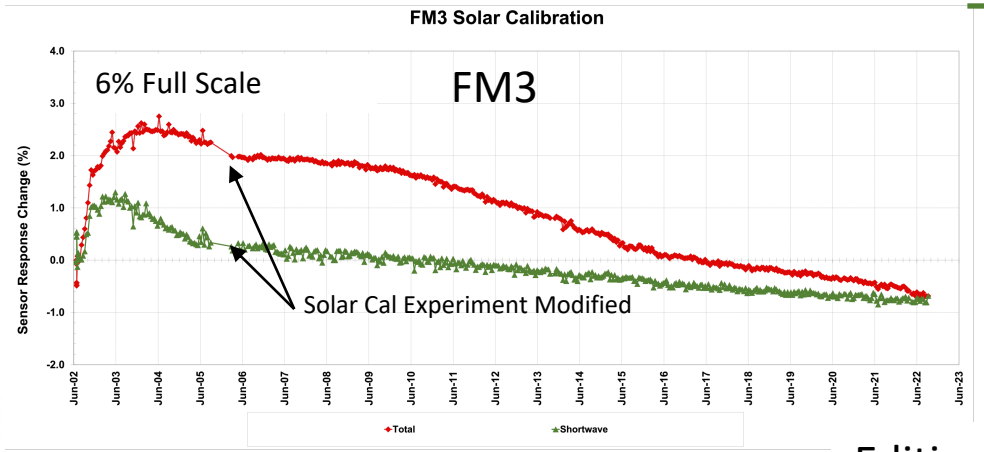
Since the start of biaxial scanning, TOT and SW channel data shows a drop of response of ~0.5% for FM2 and FM4.

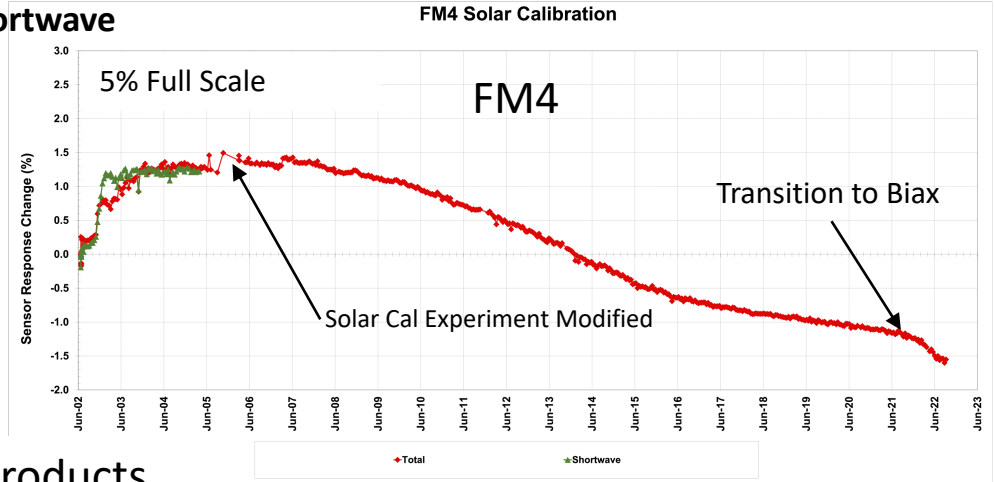




Total

Shortwave





Edition1-CV products

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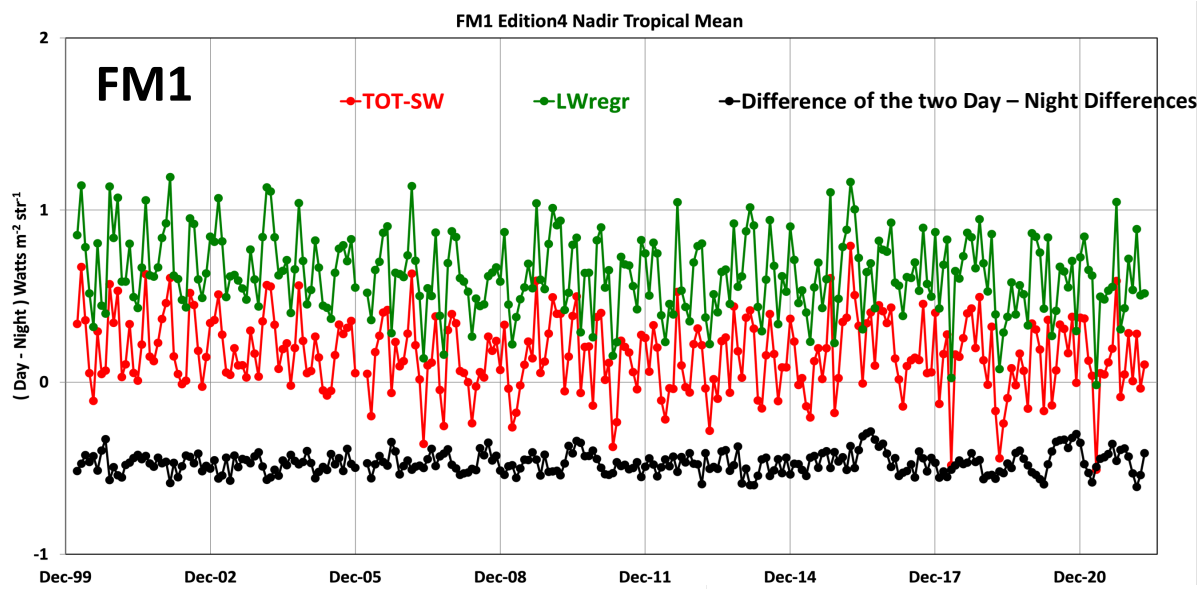
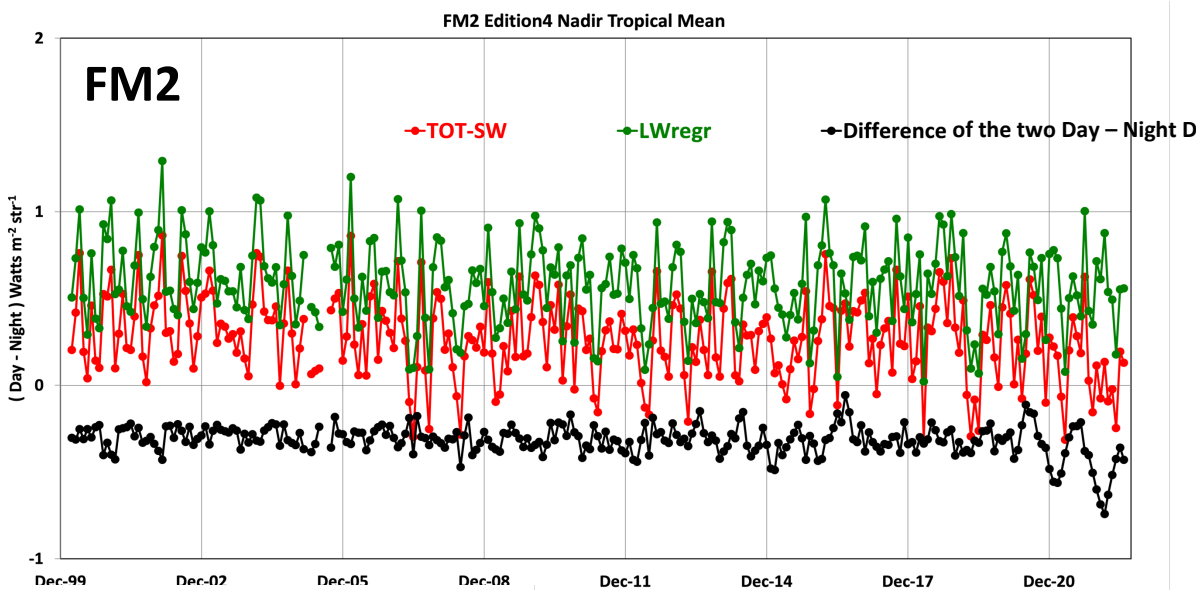
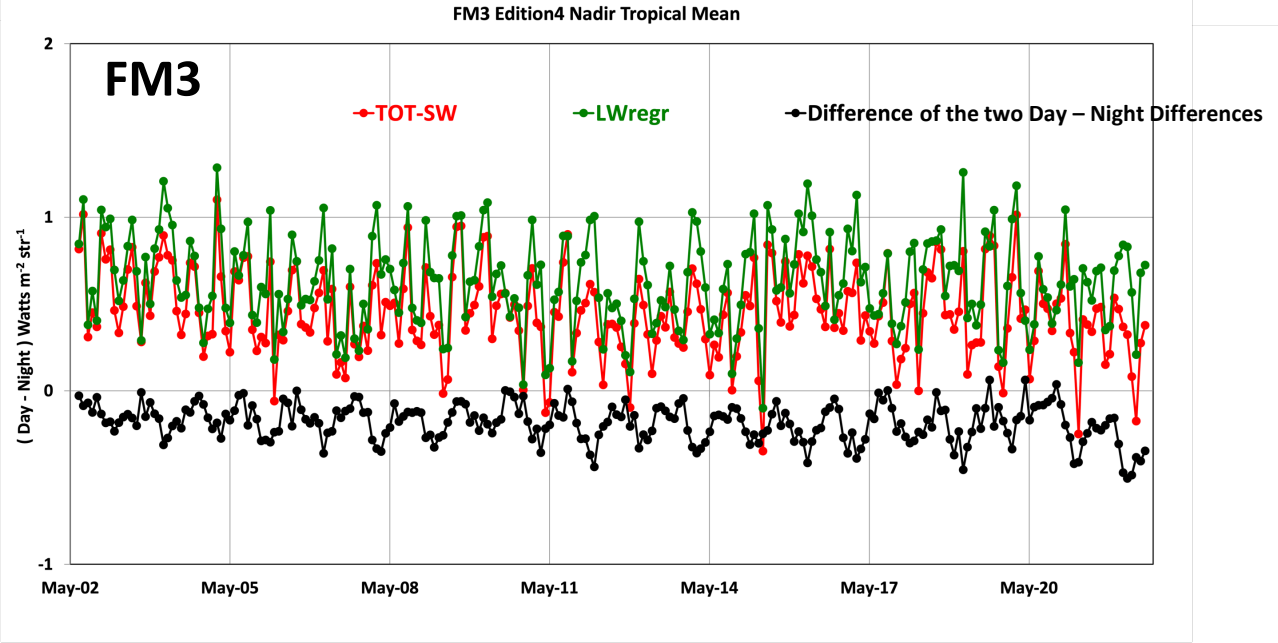
Validation- Terra and Aqua Tropical Mean







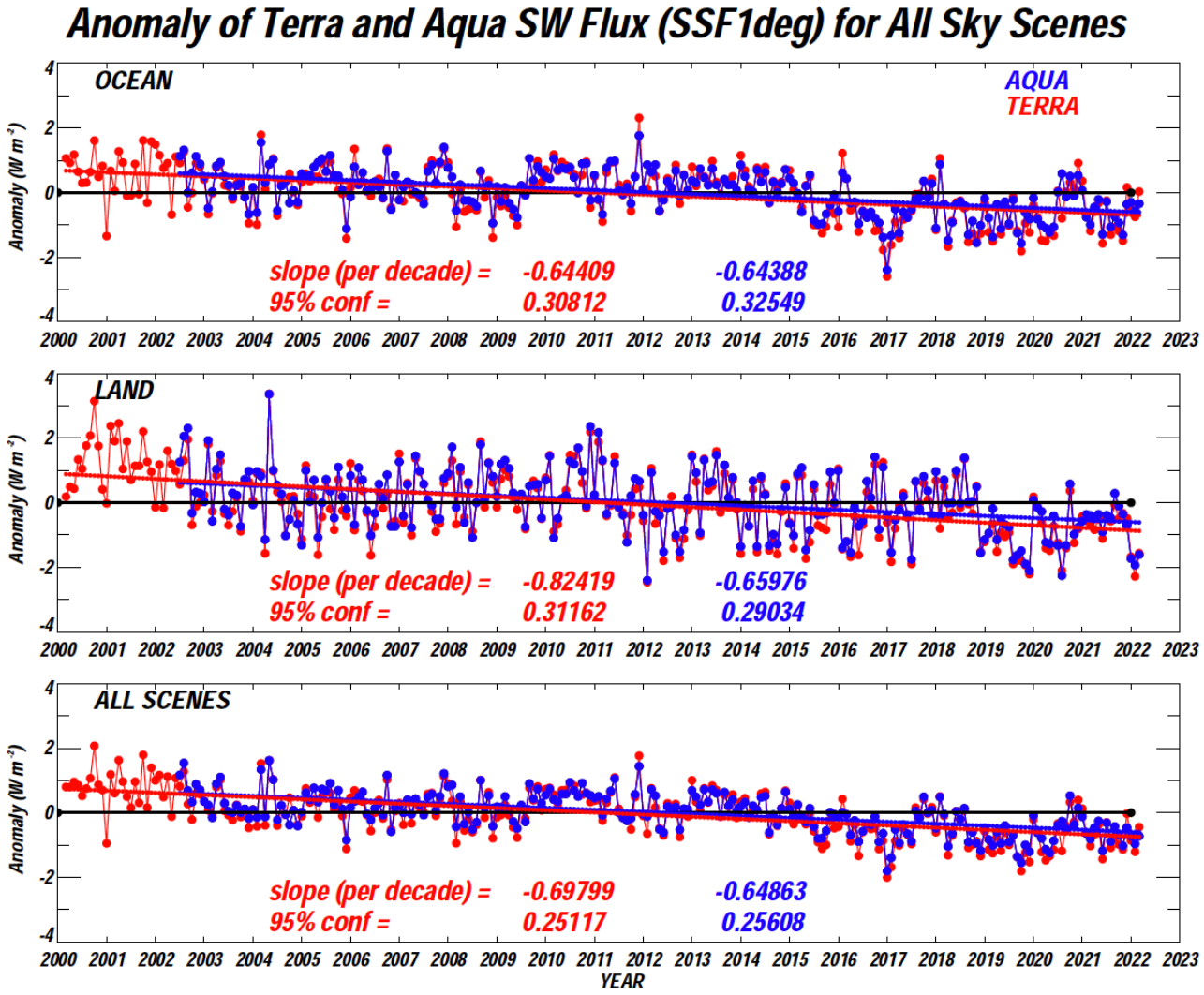
Note: Validation implies results after all Cal Updates applied

Edition4 products

Validation: Terra and Aqua Ed-4 SW Flux Anomalies

Shortwave Fluxes

Edition4 products



SW flux anomalies show similar trends for Terra and Aqua

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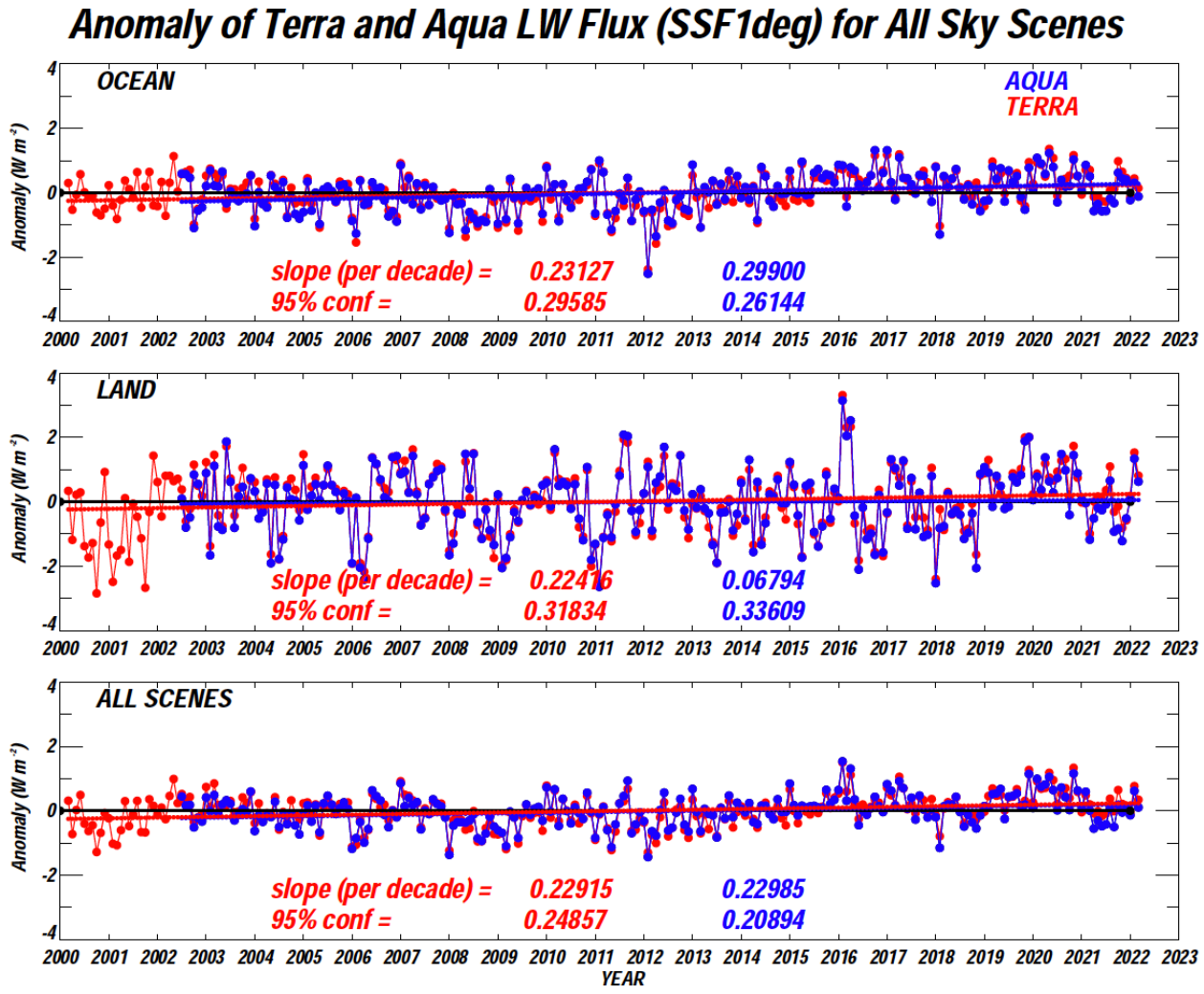
Validation: Terra and Aqua Ed-4 LW Flux Anomalies

Longwave Fluxes

Edition4 products



LW flux anomalies show similar trends for Terra and Aqua.

SUMMARY

- **All CERES instruments continue to perform nominally.**
  - **NOAA-20/FM6 instrument on-board calibrations continue to show the sensors' stable performance after the initial response rise.**
  - **S-NPP/FM5 is currently operating in biaxial mode, collecting ADM data.**
    - ***No evidence of deviation of instrument performance since transitioning to biaxial mode.***
    - ***FM5 has successfully recovered from S-NPP anomaly and subsequent stall condition.***
  - **Validations show that all instruments are performing consistently.**
- **Data products**
  - **NOAA-20/FM6 Edition 1 gains have been finalized and delivered through August 2022.**
  - **S-NPP/FM5 Edition 2 gains and SRFs have been delivered through July 2022.**
  - **Terra and Aqua instruments' Edition 4 gains and SRFs have been delivered through July 2022.**
- **Members of the IWG continue to engage with the Libera team through bi-weekly Cal/Val Working group meetings.**